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SCIENCE

A WEEKLY JOURNAL DEVOTED TO THE ADVANCEMENT OF SCIENCE, PUBLISHING THE
OFFICIAL NOTICES AND PROCEEDINGS OF THE AMERICAN ASSOCIATION
FOR THE ADVANCEMENT OF SCIENCE

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THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE SECTION A—MATHEMATICS AND ASTRONOMY

THE joint sessions of Sections A and D and the Chicago Section of the American Mathematical Society constituted a most inspiring and far-reaching feature of the meetings of this section. A separate report of these sessions will appear in SCIENCE. The address of the retiring vice-president, Professor Edward Kasner, of Columbia University, was read before a joint meeting of this section and the Chicago Section of the American Mathematical Society. It was entitled "Geometry and Mechanics," and will appear in a later number of SCIENCE. The following twenty-seven papers were read at the separate meetings of Section A.

1. *Observations with the Bruce Spectrograph:* EDWIN B. FROST.
2. *Comments on the Zeiss Stereocomparator and the Spectrocomparator belonging to Yerkes Observatory:* EDWIN B. FROST.
3. *Photographic Phenomena of Comet d 1907 (Daniel):* E. E. BARNARD.
4. *On a Great Bed of Nebulosity in Sagittarius, photographed with the Bruce Telescope of the Yerkes Observatory:* E. E. BARNARD.
5. *Note on the Problem of Three Bodies:* E. O. LOVETT.
6. *The Light Curve of Delta Cephei:* JOEL STEBBINS.
7. *An Application of the Selenium Cell to Astronomical Photometry:* JOEL STEBBINS and F. C. BROWN.
8. *Observations and Explanation of the Phenomena seen at the Disappearances of the Rings of Saturn:* E. E. BARNARD.
9. *On the Twenty-foot Horizontal Solar Spectro-*

- graph of the Yerkes Observatory:* EDWIN B. FROST and PHILIP FOX.
10. *A Graphic Method for the Determination of the Orbit of a Spectroscopic Binary:* KURT LAVES.
 11. *New Tables for the Time of Sight Correction of the Earth's Orbital Motion:* KURT LAVES.
 12. *A Generalized Theory of Integral Equations:* W. D. CAIRNS.
 13. *On the Theory of Order, Static and Nascent:* G. B. HALSTED.
 14. *Singular Points in the Approximate Development of the Perturbative Function:* F. W. REED.
 15. *On a Certain Class of Algebraic Translation-surfaces:* JOHN EISLAND.
 16. *Matrices not belonging to Groups:* ARTHUR RANUM.
 17. *A Note on Interest on Reserve from Items Computed for the Uniform Report Blank:* C. H. BECKETT.
 18. *On Asymptotic Isothermic Surfaces:* A. E. YOUNG.
 19. *Some Questionable Terms and Definitions used in Elementary Mathematics:* G. A. MILLER.
 20. *The Photographic Determination of Star-colors and their Relation to Spectral Type:* J. A. PARKHURST and F. C. JORDAN.
 21. *On the Detection of the Eruptive Prominences on the Solar Disk:* PHILIP FOX.
 22. *An Investigation of the 40-inch Objective at the Yerkes Observatory:* PHILIP FOX.
 23. *The Function of a Color Filter and of Certain Plates in Astronomical Photography:* R. J. WALLACE.
 24. *The Vertical Cælostat or "Tower" Telescope of the Mt. Wilson Solar Observatory:* G. E. HALE.
 25. *Preliminary Results of a Comparative Study of the Spectra of the Limb and the Center of the Sun:* G. E. HALE and W. S. ADAMS.
 26. *A Simple Method for Reducing Spectrograms:* FRANK SCHLESINGER.
 27. *On the Probability of the Near Approach of Two Stars and on Relative Problems in the Sidereal Universe:* F. R. MOULTON.

In the absence of their respective authors the papers of Doctors Cairns, Halsted, Lovett and Ranum were read by title, and the paper by Professor Schlesinger was read by Mr. Fox. All the other papers in the above list were read by their authors, and the abstracts which follow bear num-

bers corresponding to those of the titles in this list.

1. These observations refer to recent work at the Yerkes Observatory on stars having interesting spectra and include some new spectroscopic binaries.

2. In this second paper by Professor Frost he described the satisfactory experience with the instruments mentioned in the title. Although they have been in use for only a few months, their merits appear fully established.

3. This comet became a large one, visible to the naked eye in July and August. With the eye alone, the maximum length of the tail was about 17° , but the photographs showed that it really attained a length of some 25° .

The comet was photographed on every possible occasion with the Bruce photographic telescope of the Yerkes Observatory. Though these pictures showed very rapid changes in the form and general structure of the tail, they did not reveal any new phenomena.

The most interesting feature was a large mass of cometary matter that was thrown off from the head about July 11. Photographs made of the comet by M. Quenesett in France, by the writer at the Yerkes Observatory and by Mr. Duncan at the Lick Observatory on that date showed that this mass, though it was left behind by the comet, partook of its sunward motion, for it drifted slowly towards the sun throughout the period covered by the photographs. Professor Barnard exhibited a number of lantern slides which showed the changes in the tail.

4. In his second paper Professor Barnard gives new nebulous stars and nebulosities shown on photographs made by him in the pure atmosphere of Mt. Wilson in the summer of 1905. He also showed that nebulae M 17, M 16 and M 8 have wide extensions of feeble nebulosity that greatly

increase their previously known sizes, and he located and described nebulous regions situated in the constellation Sagittarius.

5. In this paper Professor Lovett constructs a problem of three bodies possessing exact transcendental solutions defined by finite equations; these solutions reduce to the Lagrangian solutions of the classic problem of three bodies when the ideal problem assumes the Newtonian form. The paper is a part of an extended memoir which is not ready yet for publication.

6. Professor Stebbins gives the results of a long series of photometric observations of the well-known variable star Delta Cephei. The measures were made with a polarizing photometer attached to a twelve-inch refractor. On each night 96 comparisons of the variable and companion star were taken, the entire series comprising more than 7,000 settings. The observations were combined by the method of overlapping means, and the resulting light curve shows two secondary fluctuations in addition to the main variation in brightness. No complete determination of the variation in radial velocity has been made for this star, and new measures with a modern spectrograph would throw some light upon the conditions that exist in this interesting system.

7. The authors connected a selenium cell as one arm of the ordinary Wheatstone bridge, and an exposure of the cell to light decreased its resistance and caused a deflection of the galvanometer. One observer would point the cell at the moon and make an exposure of ten seconds, while the other observer, situated in a separate room with the remainder of the apparatus, would read the galvanometer. From a series of additional exposures on a standard candle at different distances, the moon's light was determined in terms of candle power at 1 meter. A curve of the variation of moonlight with phase was shown,

and from this was derived that the full moon is approximately nine times as bright as the half moon. It was also found that the moon is brighter between first quarter and full than in the corresponding phase after full moon.

Different cells gave discordant values for the candle power of the moon, and it was shown that this must be due to the different color sensibilities of the cells. The relative sensibility for different wavelengths was determined for each cell, and it was found that no two of the cells had the same color curve. In all cases there is a maximum at about λ 7,000, but the two Giltay cells have each another maximum near λ 6,000. It was therefore concluded that selenium cells differ much as do photographic plates as regards color sensibility.

For measures of starlight a special small cell was obtained from Giltay, and by placing this cell in the focus of a 12-inch refractor, it was possible to obtain galvanometer deflections caused by the light from bright stars. Some results of the first night were given, the scale being 5 meters from the galvanometer, and the deflections as follows:

Star	Magnitude	Deflection
Mars	9.0	m.m.
α Tauri	1.0	3.4
α Arietis	2.1	1.3
β Arietis	2.8	0.8
γ Arietis	4.0	visible

These measures were made with a galvanometer which is not very sensitive, and it is hoped that the accuracy of the observations will be considerably increased when a new and more sensitive galvanometer is obtained. If it becomes possible to eliminate the effect of several disturbing factors, especially that of temperature change, there is no doubt that accurate measures of starlight can be made with selenium cells.

8. In July, October and November when there was no direct sunlight shining on the ring the entire ring was distinctly visible with the 40-inch telescope of the Yerkes Observatory.

On July 2 there were two luminous conspicuous masses or condensations visible on the ansæ, both preceding and following. As the visible surface of the ring and the condensations were on the shadow side of the ring where no direct sunlight could fall, the natural conclusion would be that the rings must be self-luminous. But this, from the nature of the constitution of the rings, is shown to be impossible.

The explanation given for this phenomenon is that the sunlight sifts through among the particles composing the rings, and by diffusion, or scattering and reflection, the dark side becomes luminous. Micrometer measures show that the condensations fall on the bright outer portion of the inner bright ring and on its projection near the planet. It is believed that the greater density of this part of the ring makes it more luminous when seen from underneath—just as it appears when the direct sunlight falls on it. In reality what we have seen, therefore, is the surface of the ring seen at a very oblique angle, where it is less than 1" of arc in width, illuminated by the sunlight percolating through the rings, similar to the sunlit view that we get of the rings, but far more feebly illuminated. That these bright places are not real elevations above the surface of the ring is shown by the fact that they disappeared when the edge of the ring was toward us, at which time they should have been better seen if they were masses on the ring. The eye was simply deceived by their greater brightness, which gave them the appearance of being masses on the ring.

9. Professor Frost gave a description of a solar spectrograph recently mounted in the Snow building of the Yerkes Observa-

tory and explained some preliminary results obtained by means of this instrument.

10. The new method here presented by Professor Laves rests on the geometric properties of the hodographic circle. It shows that from the observed maximum and minimum velocities we can determine K and $Ke \cos \omega$ where K is the radius of the hodographic circle, e the eccentricity of the orbit and ω the longitude of the periastron. By Schwarzschild's proceeding the time of periastron-passage is determined from the course of velocities. The velocity at periastron derived from the same curve furnishes two points in the hodograph of which the one of the two is the periastron. The diameter through this point cuts the chord of central distance $Ke \cos \omega$ in the focus. The values of e and ω are read off by a finely graduated scale.

11. Professor Schlesinger's tables for b and c are based on a previous transformation of the equatorial coordinates α, δ of a star into λ, β , its ecliptical coordinates. The present tables do away with this transformation and furnish at once the right ascension A and declination D of the apex of the earth's motion. The correction x is brought upon the following form :

$$x = V \{ \sin \delta \sin D + \cos \delta \cos D \cos (\alpha - A) \}.$$

The quantities $V \sin D$, $V \cos D$ and A are tabulated for every other degree of the circumference. Tables of difference for 1' change in each one of these tabulated quantities are added to facilitate the calculation. This paper will be published in the *Astrophysical Journal*.

12. The paper by Professor Cairns is devoted to a generalization of the Hilbert theory of a quadratic form in an infinite number of variables. It embodies the results reached in work carried out as part of the requirement for the degree of doctor of philosophy at Göttingen. The investigation arose in seeking to adapt the method

of integral equations to the isoperimetric problem of the calculus of variation.

13. Professor Halsted considered the essence of inherent order, its foundation, genesis, and the uses of inherently ordered series in the attribution of factitious order to primarily unordered assemblages. He also investigated the betweenness relation, both linear and of more than one dimension.

14. The method of approximation developed by Poincaré for obtaining the terms of higher order of the perturbative function depends uniquely upon certain singularities of this function. With suitable numerical assumptions the case of small eccentricities and a small inclination of the orbits is carried out in detail by Dr. Reed, and the results to be found by varying the elements are indicated.

15. The paper by Professor Eisland contains a treatment of all the types of translation-surfaces which are determined by a unicursal quartic in the plane at infinity. The most important result is: To a unicursal quartic with three real double points correspond triply infinite types of translation-surfaces of a particular form. This paper is a continuation of one recently published in the *American Journal of Mathematics* by the same author under the title "On a Certain Class of Algebraic Translation-surfaces." It will appear in the same journal.

16. Dr. Ranum proved the following theorems: If S is a singular matrix not belonging to any group, then if the number of zero roots of its characteristic equation is s , there always exists a positive integer m which does not exceed s , such that S^m belongs to some group. If m is the lowest integer having this property then among the invariant factors of the characteristic determinant of S corresponding to zero roots there is at least one of order m and none of higher order.

17. There is a discrepancy between the mathematical theory involved in the fundamental calculations of life, insurance contingencies and the policy contract itself which leaves some latitude and consequent confusion. The object of Professor Beckett's paper was to set forth this discrepancy and to find a solution that can be checked from the other items required to be computed and exhibited in the report of a company.

18. Surfaces characterized by having isothermal asymptotic lines and isothermal lines of curvature Dr. Young has called asymptotic-isothermic. In the present paper he considers special classes of such surfaces and thereby completes along certain lines a paper which he read before the Chicago Section of the American Mathematical Society several months earlier.

19. The term division has two distinct meanings in elementary mathematics. According to one of these it implies the operation of finding an integral quotient and an integral remainder, while according to the other it implies the finding of a number which, multiplied into the divisor, produces the dividend. While only the latter is the inverse of multiplication, yet it is customary to speak of division as an inverse operation without specifying which of the two commonly accepted definitions of the term is meant. A very common definition of multiplication is the performing upon the multiplicand the same operation as that which is performed upon unity to get the multiplier. The vagueness of this definition follows directly from the fact that 4 may be obtained by doubling unity and squaring the result, yet multiplying by 4 does not generally mean doubling the multiplicand and squaring the result. Such vague definitions are contrary to the very essence of mathematics and hence should be avoided.

Especial stress was laid by Professor

Miller upon the fact that dividing by 0 should be banished from elementary mathematics. The so-called indeterminate forms are really meaningless forms and it is questionable whether one should speak of evaluating such a form. As $uv=0$ has not always for its locus the combined loci of $u=0$ and $v=0$ the rule relating to this case should be stated with the necessary restrictions. The fact that the last letters of the alphabet are used both for variables and for unknowns in elementary algebra has led some authors to speak of these two very distinct concepts as if they were identical. This is the more unfortunate since the concept of a variable is continually playing a more fundamental rôle in elementary algebra. This paper will appear in *School Science and Mathematics*.

20. Photographic and visual magnitudes are determined in immediate succession with the 24-inch reflecting telescope; the photographic on ordinary plates, the visual on orthochromatic plates used with a suitable color-filter. The spectral types are obtained with an objective prism used on a 6-inch Zeiss doublet. The difference between the photographic and visual magnitudes, zero for white stars, increases progressively with the intensity of color and with the change in spectral type, giving a measure of color.

The distinctive features of the present work are: (1) The substitution of measures for eye-estimates of star-color, (2) the comparison of measured colors with spectral types.

Star colors ranging from $\frac{1}{2}$ to 5 or more magnitudes are found for types *F* to *N* in the Harvard classification. It is proposed to use these color-values as an improved method of stating star-colors. The paper will appear in the *Astrophysical Journal*.

21. In this paper Mr. Fox presents the evidences proving the identity of certain features seen on the calcium spectro-

heliograms and the eruptive prominences.

22. The objective was tested for zonal and astigmatic errors by Hartmann's method. The astigmatic errors are negligibly small. Hartmann has introduced a criterion for comparing various objectives, which is the mean diameter of the star image from the various investigated zones of the objective upon the mean focal plane expressed in 1/100,000 of the focal length. Data were given for the 40-inch objective of Yerkes Observatory and diagrams were exhibited. This paper will appear in the *Astrophysical Journal*.

23. Mr. Wallace considered the following points: Importance of the method to astronomers in general. Factors governing successful photographic results and the rôle of personality. The requirements and adjustment of filter and plate to the visual refracting telescope, illustrated by color curves of filters, plates and objective, and their combined effect upon the images obtained. Halation, and its influence upon the recording of faint or delicate details.

24. The paper describes a vertical cœlostat telescope recently erected on Mount Wilson. A 12-inch objective, mounted at the summit of a steel tower 65 feet in height, receives the sun's rays from a cœlostat and second mirror and forms an image in a house at the base of the tower. Professor Hale stated that the principal advantages of this instrument, as compared with the Snow telescope, are the better definition of the solar image and the much smaller change of focus during a given exposure of the mirrors to the sun. Photographs of the spectra of sun-spots made in the fourth order of a Littrow spectrograph of 30 feet focal length, mounted in a pit, excavated in the earth underneath the tower, were projected on the screen.

25. Solar spectra, corresponding to

points at the center and near the limb of the sun's disk, were photographed side by side on the same plate with a Littrow or auto-collimating spectrograph of 18 feet focal length, used in conjunction with the Snow telescope of the Mount Wilson Solar Observatory. The third or fourth orders of a 4-inch plane grating, having 14,438 lines to the inch, were employed. For the measurement of line displacements, spectra were photographed at points near the limb lying at opposite ends of a solar diameter, thus permitting the rotational shifts to be eliminated. Some of the more recent work has been done with a Littrow spectrograph of 30 feet focal length, used with the new vertical cœlostat or "tower" telescope of the Solar Observatory. This instrument is of the same focal length as the Snow telescope (60 feet), and thus the diameter of the solar image is about 6.7 inches in each case. The 4-inch grating, when used with the 30-foot spectrograph, gives a scale of 1 mm. = 0.58 Ångströms in the third order and 1 mm. = 0.44 Ångströms in the fourth order. As the Fraunhofer lines are fairly sharp on the photographs, this great scale permits a high degree of precision to be attained in their measurement. Up to the present time, most of the work has been done in the region $\lambda 3,800 - \lambda 5,800$. It is therefore quite possible that the preliminary results given in this paper may not apply below *D* or in the ultra-violet. These results may be summarized as follows:

1. Most of the lines shown by our photographs of spot spectra to be strengthened or weakened in sun-spots, are similarly affected near the limb.
2. Many lines not affected in spots are strengthened or weakened near the limb.
3. Lines due to substances of high atomic weight are, in general, greatly weakened near the limb.

4. Winged lines undergo marked change in appearance, the wings being greatly reduced near the limb.

5. Among the lines considerably strengthened near the limb the most important are due to elements of comparatively low atomic weight. These include the *D* lines of sodium, the *b* lines of magnesium and the blue calcium line at $\lambda 4,227$.

6. Most of the lines in the spectrum are slightly widened near the limb.

7. Most of the lines are shifted toward the red, as compared with their position at the center of the sun.

8. These displacements are not due to ascending currents at the center of the sun (which would produce negative displacements of the lines in the solar comparison spectrum), since they have also been measured with the aid of an arc comparison spectrum.

9. The magnitude of the shift varies for different lines of the same element.

10. The strengthened lines, as a rule, seem to show smaller shifts than do the other lines.

11. The spark lines of a given element, as a rule, show larger shifts than do the other lines.

12. In many cases the relative displacements of the lines agree fairly well with those obtained by Humphreys in his laboratory experiments on the effect of pressure on wave-length.

13. The lines of the cyanogen flutings ($\lambda 3,883.5$ and $\lambda 4,216.14$) are not shifted from their normal positions.

14. The shifts of groups of titanium lines near $\lambda 3,900$, $\lambda 4,500$ and $\lambda 5,300$, and of groups of iron lines near $\lambda 3,800$, $\lambda 4,400$, $\lambda 4,900$ and $\lambda 5,500$, show progressive increase toward the red, and seem to indicate that the average pressure shift, for similar lines, is a function of the wave-length.

15. Photographs taken at intermediate points between center and limb indicate that the shifts fall off rapidly, and become very small at a short distance from the limb.

26. In order to obtain radial velocities from star lines that are not present in the comparison spectrum it is customary to use an interpolation formula to express the exact relation between wave-lengths and micrometer readings. These formulæ do not change much from plate to plate if the latter are all taken with the same spectrograph, and whatever differences there may be can be *largely* allowed for by adding to the micrometer readings (R) a linear expression: $a + b \cdot R$. Assuming that this is rigorously the case for short distances on the plate, it is shown that the error of this assumption can amount to a few hundredths of a kilometer per second in the case of plates taken with the Mellon Spectrograph of the Allegheny Observatory. Consequently it is only necessary to interpolate the place of a star line linearly between two comparison lines in order to obtain its displacement. This method has been tried on many plates at the Allegheny Observatory and has been found very convenient. The complete reduction of a plate in this way occupies about ten minutes.

27. The problem of Professor Moulton's paper is to find the possible rôle that the near approaches of the stars to one another may have played in sidereal evolution. The answer to this problem depends upon the extent of the sidereal universe, the number of stars in it, and the character of their motion. The discussion leads to the conclusion that the relatively near approaches of the stars have probably been an important factor in stellar evolution. The paper will be published by the Carnegie Institution.

The general committee elected Professor C. J. Keyser, Columbia University, vice-president and chairman of the Section, and Professor G. A. Miller, University of Illinois, secretary. The Section elected Professor G. B. Halsted, councilor; Professor F. R. Moulton, member of the general committee; Professors E. W. Brown and F. R. Moulton, members of the sectional committee—the former for five years and the latter for four years.

G. A. MILLER,
Secretary

UNIVERSITY OF ILLINOIS

THE AMERICAN MATHEMATICAL SOCIETY

THE fourteenth annual meeting of the American Mathematical Society was held at Columbia University on Friday and Saturday, December 27-28, 1907, extending through two sessions on Friday and a session on Saturday morning. The attendance included fifty-three members. President H. S. White occupied the chair, being relieved by Vice-president P. F. Smith at the afternoon session. The following were elected to membership in the society: Mr. Charles Ammerman, McKinley High School, St. Louis, Mo.; Dr. C. S. Atchison, Williams College; Mr. B. H. Camp, Wesleyan University; Professor W. M. Carruth, Hamilton College; Mr. G. R. Clements, Williams College; Professor Julia T. Colpitts, Iowa State College; Professor J. N. Ivey, Tulane University; Professor W. H. Jackson, Haverford College; Mr. W. C. Krathwohl, Columbia University; Professor Murray Macneill, Dalhousie University; Mr. C. N. Moore, Harvard University; Professor Maria M. Roberts, Iowa State College; Mr. E. W. Sheldon, Yale University. Seven applications for membership were received.

In response to the invitation of Professor E. J. Townsend, it was decided to hold the